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R E M A R K S
UPON
T H E N A T U R E
O F
T H E S O I L O F N A P L E S,
A N D
I T S N E I G H B O U R H O O D:

IN A LETTER FROM
The Honourable WILLIAM HAMILTON,
His MAJESTY'S ENVOY EXTRAORDINARY at NAPLES,
TO MATTHEW MATY, M. D. Sec. R. S.

K

Read before the ROYAL SOCIETY, Jan. 10, 17, and 24, 1771.

L O N D O N,
Printed by W. BOWYER and J. NICHOLS.

M.DCC.LXXI.

R E M A R K S

THE NATURE

THE SOIL ON NARLES

AND



The Honorable WILLIAM HAMILTON

His Majesty's Secretary of State for the Colonies

To Matthew M. M. M. M. M.

Printed by the Royal Government, London, 1871

London

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To Mathew Maty, M. D. Sec. R. S.

S I R,

Naples, Oct. 16, 1770.

A C C O R D I N G to your desire, I lose no time in sending you such further remarks as I have been making with some diligence, for six years past, in the compass of twenty miles or more, round this capital. By accompanying these remarks with a map of the country I describe, and with the specimens of different matters that compose the most remarkable spots of it,
B I do

I do not doubt but that I shall convince you, as I am myself convinced, that the whole circuit (so far as I have examined) within the boundaries marked in the map, is wholly and totally the production of subterraneous fires; and that most probably the sea formerly reached the mountains that lie behind Capua and Caserta, and are a continuation of the Appennines. If I may be allowed to compare small things with great, I imagine the subterraneous fires to have worked in this country under the bottom of the sea, as moles in a field, throwing up here and there a hillock, and that the matter thrown out of some of these hillocks formed into settled volcanos, filling up the space between one and the other, has composed this part of the continent, and many of the islands adjoining.

From the observations I have made upon mount Etna, Vesuvius, and its neighbourhood, I dare say, that, after a careful examination, most mountains that are, or have been volcanos, would be found to owe their existence to subterraneous fire; the direct reverse of what I find the commonly received opinion.

Nature, though varied, is certainly in general uniform in her operations; and I cannot conceive that two such considerable volcanos as Etna and Vesuvius should have been formed otherwise, than every other considerable volcano of the known world. I do not wonder that so little progress has been made in the improvement of natural history, and particularly in that branch of it which regards the theory of the earth; nature acts slowly, it is difficult to catch her in the fact. Those who have made this
subject

subject their study have, without scruple, undertaken at once, to write the natural history of a whole province, or of an entire continent; not reflecting, that the longest life of man scarcely affords him time to give a perfect one of the smallest insect.

I am sensible of what I undertake in giving you, Sir, even a very imperfect account of the nature of the soil of a little more than twenty miles round Naples: yet I flatter myself that my remarks, such as they are, may be of some use to any one hereafter, who may have leisure and inclination to follow them up. The kingdom of the Two Sicilies offers certainly the fairest field for observations of this kind, of any in the whole world; here are volcanos existing in their full force, some on their decline, and others totally extinct.

To begin with some degree of order, which is really difficult in the variety of matter that occurs to my mind, I will first mention the basis on which I found all my conjectures. It is the nature of the soil that covers the antient towns of Herculaneum and Pompeii, and the interior and exterior form of the new mountain, near Puzzole, with the sort of materials of which it is composed. It cannot be denied that Herculaneum and Pompeii stood once above ground; though now, the former is in no part less than seventy feet, and in some parts one hundred and twelve feet, below the present surface of the earth; and the latter is buried ten or twelve feet deep, more or less. As we know from the very accurate account given by Pliny the younger, to Tacitus, and from the accounts of other contemporary authors, that these towns were buried by an eruption

of mount Vesuvius in the time of Titus; it must be allowed, that whatever matter lies between these cities and the present surface of the earth over them, must have been produced since the year 79 of the Christian æra, the date of that formidable eruption.

Pompeii, which is situated at a much greater distance from the volcano than Herculaneum, has felt the effects of a single eruption only; it is covered with white pumice stones mixed with fragments of lava and burnt matter, large and small; the pumice is very light, but I have found some of the fragments of lava and cinders there, weighing eight pounds. I have often wondered that such weighty bodies could have been carried to such a distance (for Pompeii cannot be less than five miles, in a strait line, from the mouth of Vesuvius). Every observation confirms the fall of this horrid shower over the unfortunate city of Pompeii, and that few of its inhabitants had dared to venture out of their houses; for in many of those which have been already cleared, skeletons have been found, some with gold rings, ear rings, and bracelets. I have been present at the discovery of several human skeletons myself; and under a vaulted arch, about two years ago, at Pompeii, I saw the bones of a man and a horse taken up, with the fragments of the horse's furniture, which had been ornamented with false gems set in bronze. The skulls of some of the skeletons found in the streets had been evidently fractured by the fall of the stones. His Sicilian majesty's excavations are confined to this spot at present; and the curious in antiquity may expect hereafter, from so rich a mine, ample matter for their dissertations: but I will confine myself
to

to such observations only as relate to my present subject.

Over the stratum of pumice and burnt matter that covers Pompeii, there is a stratum of good mould, of the thickness of about two feet and more in some parts, in which vines flourish, except in some particular spots of this vineyard, where they are subject to be blasted by a foul vapour or *mofete*, as it is called here, that rises from beneath the burnt matter. The abovementioned shower of pumice stones, according to my observations, extended beyond Castel-a-mare (near which spot the ancient town of Stabia also lies buried under them), and covered a tract of country not less than thirty miles in circumference. It was at Stabia that Pliny the elder lost his life, and this shower of pumice stones is well described in the younger Pliny's letter. Little of the matter that has issued from Vesuvius since that time, has reached these parts: but I must observe that the pavement of the streets of Pompeii is of lava; nay, under the foundation of the town, there is a deep stratum of lava and burnt matter. These circumstances, with many others that will be related hereafter, prove, beyond a doubt, that there have been eruptions of Vesuvius previous to that of the year 79, which is the first recorded by history.

The growth of soil by time is easily accounted for; and who, that has visited ruins of ancient edifices, has not often seen a flourishing shrub, in a good soil, upon the top of an old wall? I have remarked many such on the most considerable ruins at Rome and elsewhere. But from the soil which has grown over the barren pumice that covers Pompeii, I was enabled

enabled to make a curious observation. Upon examining the cuts and hollow ways made by currents of water in the neighbourhood of Vesuvius and of other volcanos, I had remarked that there lay frequently a stratum of rich soil, of more or less depth, between the matter produced by the explosion of succeeding eruptions; and I was naturally led to think that such a stratum had grown in the same manner as the one abovementioned over the pumice of Pompeii. Where the stratum of good soil was thick, it was evident to me that many years had elapsed between one eruption and that which succeeded it. I do not pretend to say that a just estimate can be formed of the great age of volcanos from this observation, but some sort of calculation might be made; for instance, should an explosion of pumice cover again the spot under which Pompeii is buried, the stratum of rich soil abovementioned would certainly lie between two beds of pumice; and if a like accident had happened a thousand years ago, the stratum of rich soil would as certainly have wanted much of its present thickness, as the rotting of vegetables, manure, &c. is ever increasing a cultivated soil. Whenever I find then a succession of different strata of pumice and burnt matter like that which covers Pompeii, intermixed with strata of rich soil, of greater or less depth, I hope I may be allowed reasonably to conclude, that the whole has been the production of a long series of eruptions occasioned by subterraneous fire. By the size and weight of the pumice, and fragments of burnt erupted matter in these strata, it is easy to trace them up to their source, which I have done more than once in the neighbourhood

hood of Puzzole, where explosions have been frequent. The gradual decrease in the size and quantity of the erupted matter in the stratum above-mentioned, from Pompeii to Castle-a-Mare, is very visible: at Pompeii, as I said before, I have found them of eight pounds weight, when at Castle-a-Mare the largest do not weigh an ounce.

The matter which covers the ancient town of Herculaneum is not the produce of one eruption only; for there are evident marks that the matter of six eruptions has taken its course over that which lies immediately above the town, and was the cause of its destruction. These strata are either of lava or burnt matter, with veins of good soil between them. The stratum of erupted matter that immediately covers the town, and with which the theatre and most of the houses were filled, is not of that foul vitrified matter, called lava, but of a sort of soft stone, composed of pumice, ashes, and burnt matter. It is exactly of the same nature with what is called here the Naples stone; the Italians distinguish it by the name of *tufa*, and it is in general use for building. Its colour is usually that of our free stone, but sometimes tinged with grey, green, and yellow; and the pumice stones, with which it ever abounds, are sometimes large and sometimes small: it varies likewise in its degree of solidity.

The chief article in the composition of this *tufa* seems to me to be, that fine burnt material, which is called *puzzolane*, whose binding quality and utility by way of cement are mentioned by Vitruvius, and which is to be met with only in countries that have been subject to subterraneous fires. It is, I believe, a sort of lime prepared

pared by nature. This, mixed with water, great or small pumice stones, fragments of lava, and burnt matter, may naturally be supposed to harden into a stone of this kind; and, as water frequently attends eruptions of fire, as will be seen in the accounts I shall give of the formation of the new mountain near Puzzole, I am convinced the first matter that issued from Vesuvius, and covered Herculaneum, was in the state of liquid mud. A circumstance strongly favouring my opinion is, that, about two years ago, I saw the head of an antique statue dug out of this matter within the theatre of Herculaneum; the impression of its face remains to this day in the *tufa*, and might serve as a mould for a cast in plaister of Paris, being as perfect as any mould I ever saw. As much may be inferred from the exact resemblance of this matter, or *tufa*, which immediately covers Herculaneum, to all the *tufa's* of which the high grounds of Naples and its neighbourhood are composed; I detached a piece of it sticking to, and incorporated with, the painted stucco of the inside of the theatre of Herculaneum, and shall send it for your inspection *. It is very different, as you will see, from the vitrified matter called lava, by which it has been generally thought that Herculaneum was destroyed. The village of Refina and some villas stand at present above this unfortunate town.

To account for the very great difference of the matters that cover Herculaneum and Pompeii, I have often thought that in the eruption of 79 the moun-

* This piece is now in the Museum of the Royal Society, together with many other specimens, mentioned in this and in the following letter. M. M.

tain must have been open in more than one place. A passage in Pliny's letter to Tacitus seems to say as much, "*Interim e Vesuvio monte pluribus locis latissimæ flammæ, atque incendia relucebant, quorum fulgor et claritas tenebras noctis pellebat :*" so that very probably the matter that covers Pompeii proceeded from a mouth, or crater, much nearer to it than is the great mouth of the volcano, from whence came the matter that covers Herculaneum. This matter might nevertheless be said to have proceeded from Vesuvius, just as the eruption in the year 1760, which was quite independent of the great crater (being four miles from it), is properly called an eruption of Vesuvius.

In the beginning of eruptions, volcanos frequently throw up water mixed with the ashes. Vesuvius did so in the eruption of 1631, according to the testimony of many contemporary writers. The same circumstance happened in 1669 according to the account of Ignazzio Sorrentino, who, by his History of Mount Vesuvius printed at Naples in 1734, has shewn himself to have been a very accurate observer of the phænomena of the volcano, for many years that he lived at Torre del Greco, situated at the foot of it. At the beginning of the formation of the new mountain, near Puzzole, water was mixed with the ashes thrown up, as will be seen in two very curious and particular accounts of the formation of that mountain, which I shall have the pleasure of communicating to you presently; and in 1755 Etna threw up a quantity of water in the beginning of an eruption, as is mentioned in the letter I sent you last

C

year

year upon the subject of that magnificent volcano*. Ulloa likewise mentions this circumstance of water attending the eruptions of volcanos in America. Whenever therefore I find a *tufa* composed exactly like that which immediately covers Herculaneum, and undoubtedly proceeded from Vesuvius, I conclude such a *tufa* to have been produced by water mixing with the erupted matter at the time of an explosion occasioned by subterraneous fire; and this observation, I believe, will be of more use than any other, in pointing out those parts of the present *terra firma*, that have been formed by explosion. I am convinced it has often happened that subterraneous fires and exhalations, after having been pent up and confined for some time, and been the cause of earthquakes, have forced their passage, and in venting themselves formed mountains of the matter that confined them, as you will see was the case near Puzzole in the year 1538, and by evident signs has been so before, in many parts of the neighbourhood of Puzzole; without creating a regular volcano. The materials of such mountains will have but little appearance of having been produced by fire, to any one unaccustomed to make observations upon the different nature of volcanos.

If it were allowed to make a comparison between the earth and a human body, one might consider a country replete with combustibles occasioning explosions (which is surely the case here) to be like a body full of humours. When these humours centre in one part, and form a great tumour out of which they are discharged freely, the body is less

* Phil. Transact. Vol. LX. p. 1.

agitated;

agitated ; but when by any accident the humours are checked, and do not find a free passage through their usual channel, the body is agitated, and tumours appear in other parts of that body, but soon after the humours return again to their former channel. In a similar manner one may conceive Vesuvius to be the present great channel, through which nature discharges some of the foul humours of the earth ; when these humours are checked by any accident or stoppage in this channel for any considerable time, earthquakes will be frequent in its neighbourhood, and explosions may be apprehended even at some distance from it. This was the case in the year 1538, Vesuvius having been quiet for near 400 years. There was no eruption from its great crater from the year 1139 to the great eruption of 1631, and the top of the mountain began to lose all signs of fire. As it is not foreign to my purpose, and will serve to shew how greatly they are mistaken, who place the seat of the fire in the centre or towards the top of a volcano, I will give you a curious description of the state of the crater of Vesuvius, after having been free from eruptions 492 years, as related by Bracini, who descended into it not long before the eruption of 1631 : “ The crater was five miles in
 “ circumference, and about a thousand paces deep ; its
 “ sides were covered with brush wood, and at the
 “ bottom there was a plain on which cattle grazed.
 “ In the woody parts, boars frequently harboured ;
 “ in the midst of the plain, within the crater, was a
 “ narrow passage, through which, by a winding path,
 “ you could descend about a mile amongst rocks and
 “ stones, till you came to another more spacious
 C 2 “ plain

“ plain covered with ashes : in this plain were three
 “ little pools, placed in a triangular form, one to-
 “ wards the East, of hot water, corrosive and bitter
 “ beyond measure ; another towards the West, of
 “ water salter than that of the sea ; the third of hot
 “ water, that had no particular taste.”

The great increase of the cone of Vesuvius, from that time to this, naturally induces one to conclude, that the whole of the cone was raised in the like manner, and that the part of Vesuvius, called Somma, which is now considered as a distinct mountain from it, was composed in the same manner. This may plainly be perceived by examining its interior and exterior form, and the strata of lava and burnt matter of which it is composed. The ancients, in describing Vesuvius, never mention two mountains. Strabo, Dio, Vitruvius, all agree, that Vesuvius, in their time, shewed signs of having formerly erupted, and the first compares the crater on its top to an amphitheatre. The mountain now called Somma was, I believe, that which the ancients called Vesuvius ; its outside form is conical, its inside, instead of an amphitheatre, is now like a great theatre. I suppose the eruption in Pliny's time to have thrown down that part of the cone next the sea, which would naturally have left it in its present state, and that the conical mountain, or existing Vesuvius, has been raised by the succeeding eruptions : all my observations confirm this opinion. I have seen antient lavas in the plain on the other side of Somma, which could never have proceeded from the present Vesuvius. Serao, a celebrated physician now living at Naples, in the introduction of his account of the eruption of Vesuvius

vius in 1737 (in which account many of the phenomena of the volcano are recorded and very well accounted for) says, that at the convent of Dominican Fryars, called the Madona del Arco, some years ago, in sinking a well, at a hundred feet depth, a lava was discovered, and soon after another, so that in less than three hundred feet depth, the lavas of four eruptions were found. From the situation of this convent it is clear beyond a doubt, that these lavas proceeded from the mountain called Somma, as they are quite out of the reach of the existing volcano.

From these circumstances, and from repeated observations I have made in the neighbourhood of Vesuvius, I am sure that no virgin soil is to be found there, and that all is composed of different strata of erupted matter, even to a great depth below the level of the sea. In short, I have not any doubt in my own mind, but that this volcano took its rise from the bottom of the sea; and as the whole plain between Vesuvius and the mountains behind Caserta, which is the best part of the Campagna Felice, is (under its good soil) composed of burnt matter, I imagine the sea to have washed the feet of those mountains, until the subterraneous fires began to operate, at a period certainly of a most remote antiquity.

The soil of the Campagna Felice is very fertile; I saw the earth opened in many places last year in the midst of that plain, when they were seeking for materials to mend the road from Naples to Caserta. The stratum of good soil was in general four or five feet thick; under which was a deep stratum of cinders, pumice, fragments of lava and such burnt matter as abounds near Vesuvius and all volcanos.

The

The mountains at the back of Caserta are mostly of a sort of lime-stone, and very different from those formed by fire; though Signior Van Vitelli, the celebrated architect, has assured me, that in the cutting of the famous aqueduct of Caserta through these mountains, he met with some soils, that had been evidently formed by subterraneous fires. The high grounds which extend from Castel-a-Mare to the point of Minerva towards the island of Caprea, and from the promontory that divides the bay of Naples from that of Salerno, are of lime stone. The plain of Sorrento, that is bounded by these high grounds, beginning at the village of Vico, and ending at that of Massa, is wholly composed of the same sort of *tufa* as that about Naples, except that the cinder or pumice stones intermixed in it are larger than in the Naples *tufa*. I conceive then that there has been an explosion in this spot from the bottom of the sea. This plain, as I have remarked to be the case with all soils produced by subterraneous fire, is extremely fertile; whilst the ground about it, being of another nature, is not so. The island of Caprea does not shew any signs of having been formed by subterraneous fire, but is of the same nature as the high grounds last mentioned, from which it has been probably detached by earthquakes, or the violence of the waves. Rovigliano, an island, or rather a rock in the bay of Castel-a-Mare, is likewise of lime stone, and seems to have belonged to the original mountains in its neighbourhood: in some of these mountains there are also petrified fish and fossil shells, which I never have found in the mountains, which I suppose to have been formed by explosion.

You

You have now, Sir, before you the nature of the soil, from Caprea to Naples. The soil on which this great metropolis stands has been evidently produced by explosions, some of which seem to have been upon the very spot on which this city is built; all the high grounds round Naples, Paufilipo, Puzzole, Baia, Misenum, the islands of Procita and Ischia, all appear to have been raised by explosion. You can trace still in many of these heights the conical shape that was naturally given them at first, and even the craters out of which the matter issued, though to be sure others of these heights have suffered such changes by the hand of time, that you can only conjecture that they were raised in the like manner, by their composition being exactly the same as that of those mountains, which still retain their conical form and craters entire. A *tufa*, exactly resembling the specimen I took from the inside of the theatre of Herculaneum, layers of pumice intermixed with layers of good soil, just like those over Pompeii, and lavas like those of Vesuvius, compose the whole soil of the country that remains to be described.

The famous grotto anciently cut through the mountain of Paufilipo, to make a road from Naples to Puzzole, gives you an opportunity of seeing that the whole of that mountain is *tufa*. The first evident crater you meet with, after you have passed the grotto of Paufilipo, is now the lake of Agnano; a small remain of the subterraneous fire (which must probably have made the basin for the lake, and raised the high grounds which form a sort of amphitheatre round it) serves to heat rooms, which the Neapolitans make great use of in summer, for carrying off
diverse

diverse disorders, by a strong perspiration. This place is called the Sudatorio di San Germano; near the present bagnios, which are but poor little hovels, there are the ruins of a magnificent ancient bath. About an hundred paces from hence, is the Grotto del Cane; I shall only mention, as a further proof of the probability that the lake of Agnano was a volcano, that vapours of a pernicious quality, as that in the Grotto del Cane, are frequently met with in the neighbourhood of Etna and Vesuvius, particularly at the time of, before, and after, great eruptions. The noxious vapour having continued in the same force constantly so many ages, as it has done in the Grotto del Cane (for Pliny mentions this Grotto), is indeed a circumstance in which it differs from the vapours near Vesuvius and Etna, which are not constant; the cone forming the outside of this supposed volcano is still perfect in many parts.

Opposite to the Grotto del Cane, and immediately joining to the lake, rises the mountain called Astruni, which, having, as I imagine, been thrown up by an explosion of a much later date, retains the conical shape and every symptom of a volcano in much greater perfection than that I have been describing. The crater of Astruni is surrounded with a wall to confine boars and deer (this volcano having been for many years converted to a royal chace). It may be about six miles or more in circumference; in the plain at the bottom of the crater are two lakes, and in some books there is mention made of a hot spring, which I never have been able to find. There are many huge rocks of lava within the crater of Astruni, and some I have met with also in that of Agnano; the

the cones of both these supposed volcanos are composed of *tufa* and strata of loose pumice, fragments of lava and other burnt matter, exactly resembling the strata of Vesuvius. Bartholomeus Fatius, who wrote of the actions of king Alphonso the first (before the new mountain had been formed near Puzzole), conjectured that Astruni had been a volcano. These are his words: *Locus Neapoli quatuor millia passuum proximus, quem vulgo Listrone vocant, nos unum e Phlegreeis Campis ab ardore nuncupandum putamus.* There is no entrance into the crater of either Astruni or Agnano, except one, evidently made by art, and they both exactly correspond with Strabo's description of *avenues*; the same may be said of the Solfaterra and the Monte Gauro, or Barbaro as it is sometimes called, which I shall describe presently.

Near Astruni and towards the sea rises the Solfaterra, which not only retains its cone and crater, but much of its former heat. In the plain within the crater, smoke issues from many parts, as also from its sides; here, by means of stones and tiles heaped over the crevices, through which the smoke passes, they collect in an aukward manner what they call *sale armoniaco*; and from the sand of the plain they extract sulphur and alum. This spot well attended to might certainly produce a good revenue, whereas I doubt if they have hitherto ever cleared 200 *l.* a year by it. The hollow sound produced by throwing a heavy stone on the plain of the crater of the Solfaterra seems to indicate, that it is supported by a sort of arched natural vault; and one is induced to think that there is a pool of water beneath this vault (which boils by the heat of a subterraneous fire still deeper)

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by

by the very moist stream that issues from the cracks in the plain of the Solfaterra, which, like that of boiling water, runs off a sword or knife, presented to it, in great drops. On the outside, and at the foot of the cone of the Solfaterra, towards the lake of Agnano, water rushes out of the rocks, so hot, as to raise the quicksilver in Fahrenheit's thermometer to the degree of boiling water, a fact of which I was myself an eye-witness. This place, well worthy the observation of the curious, has been taken little notice of; it is called the *Pisciarelli*. The common people of Naples have great faith in the efficacy of this water, and make much use of it in all cutaneous disorders, as well as for another disorder that prevails here. It seems to be impregnated chiefly with sulphur and alum. When you approach your ear to the rocks of the *Pisciarelli*, from whence this water ouzes, you hear a horrid boiling noise, which seems to proceed from the huge cauldron, that may be supposed to be under the plain of the Solfaterra. On the other side of the Solfaterra, next the sea, there is a rock which has communicated with the sea, till part of it was cut away to make the road to Puzzole; this was undoubtedly a considerable lava that ran from the Solfaterra when it was an active volcano. Under this rock of lava, which is more than seventy feet high, there is a stratum of pumice and ashes. This ancient lava is about a quarter of a mile broad; you meet with it abruptly before you come in sight of Puzzole, and it finishes as abruptly within about an hundred paces of the town. I have often thought that many quarries of stone upon examination would be found to owe their origin to the same cause, though
time

time may have effaced all signs of the volcano from whence they proceeded. Except this rock, which is evidently lava and full of vitrifications like that of Vesuvius, all the rocks upon the coast of Baia are of *tufa*.

I have observed in the lava of Vesuvius and Etna, as in this, that the bottom as well as the surface of it was rough and porous, like the cinders or scoræ from an iron foundery, and that for about a foot from the surface and from the bottom, they were not near so solid and compact as towards the centre; which must undoubtedly proceed from the impression of the air upon the vitrified matter whilst in fusion. I mention this circumstance, as it may serve to point out true lava's with more certainty. The ancient name of the Solfaterra was, *Forum Vulcani*, a strong proof of its origin from subterraneous fire. The degree of heat that the Solfaterra has preserved for so many ages, seems to have calcined the stones upon its cone, and in its crater, as they are very white and crumble easily in the hottest parts.

We come next to the new mountain near Puzzole, which, being of so very late a formation, preserves its conical shape entire, and produces as yet but a very slender vegetation. It has a crater almost as deep as the cone is high, which may be near a quarter of a mile perpendicular, and is in shape a regular inverted cone. At the basis of this new mountain (which is more than three miles in circumference), the sand upon the sea shore, and even that which is washed by the sea itself, is burning hot for above the space of an hundred yards; if you take up a handful of the

sand below water, you are obliged to get rid of it directly, on account of its intense heat.

I had been long very desirous of meeting with a good account of the formation of this new mountain, because, proving this mountain to have been raised by meer explosion in a plain, would prove at the same time, that all the neighbouring mountains, which are composed of the same materials, and have exactly or in part the same form, were raised in the like manner, and that the seat of fire, the cause of these explosions, lies deep, which I have every reason to think.

Fortunately, I lately found two very good accounts of the phænomena that attended the explosion, which formed the new mountain, published a few months after the event. As I think them very curious, and greatly to my purpose, and as they are rare, I will give you a literal translation of such extracts as relate to the formation of the Monte Nuovo. They are bound in one volume*.

The title of the first is *Dell Incendio di Pozzuolo, Marco Antonio delli Falconi all Illustrissima Signiora Marchesa della Padula nel MDXXXVIII.*

At the head of the second is, *Ragionamento del Terremoto, del Nuovo Monte, del Aprimento di Terra in Pozzuolo nell' Anno 1538. é della significatione d'essi. Per Piero Giacomo da Toledo; and at the end of the book, Stampata in Nap. per Giovanni Sulzbach Alemanno, a 22di Genaro 1539, con gratia, é privilegio.*

“ First then (says Marco Antonio delli Falconi),
“ will I relate simply and exactly the operations of

* This very scarce volume has been presented by Mr. Hamilton to the British Museum. M. M.

“ nature,

“ nature, of which I was either myself an eye-wit-
 “ nefs, or as they were related to me by those who
 “ had been witnesses of them. It is now two years
 “ that there have been frequent earthquakes at
 “ Pozzuolo, at Naples, and the neighbouring parts;
 “ on the day, and in the night before the appearance
 “ of this eruption, above twenty shocks great and
 “ small were felt at the abovementioned places. The
 “ eruption made its appearance the 29th of Septem-
 “ ber 1538, the feast of St Michael the angel; it was
 “ on a Sunday, about an hour in the night; and as I
 “ have been informed, they began to see on that spot,
 “ between the hot baths or sweating rooms, and
 “ Trepergule, flames of fire, which first made their
 “ appearance at the baths, then extended towards
 “ Trepergule, and fixing in the little valley that lies
 “ between the Monte Barbaro and the hillock called
 “ del Pericolo (which was the road to the lake of
 “ Avernus and the baths), in a short time the fire
 “ increased to such a degree that it burst open the
 “ earth in this place, and threw up so great a quanti-
 “ ty of ashes and pumice stones mixed with water,
 “ as covered the whole country; and in Naples a
 “ shower of these ashes and water fell great part of
 “ the night. The next morning, which was Monday,
 “ and the last of the month, the poor inhabitants of
 “ Pozzuolo, struck with so horrible a sight, quitted
 “ their habitations, covered with that muddy and
 “ black shower, which continued in that country the
 “ whole day, flying death, but with faces painted
 “ with its colours, some with their children in their
 “ arms, some with sacks full of their goods, others
 “ leading an ass loaded with their frightened family
 “ towards

“ towards Naples, others carrying quantities of birds
 “ of various sorts that had fallen dead at the time the
 “ eruption began, others again with fish which they
 “ had found, and were to be met with in plenty
 “ upon the shore, the sea having been at that time
 “ considerably dried up. Don Petro di Toledo, Vice-
 “ roy of the kingdom, with many gentlemen, went
 “ to see so wonderful an appearance; I also, having
 “ met with the most honourable and incomparable
 “ gentleman, Signior Fabritio Moramaldo, on the
 “ road, went and saw the eruption and the many
 “ wonderful effects of it. The sea towards Baïa
 “ had retired a considerable way; though from the
 “ quantity of ashes and broken pumice stones thrown
 “ up by the eruption, it appeared almost totally dry.
 “ I saw likewise two springs in those lately-discover-
 “ ed ruins, one before the house that was the queen’s,
 “ of hot and salt water; the other of fresh and cold
 “ water, on the shore, about 250 paces nearer to the
 “ eruption: some say, that still nearer to the spot
 “ where the eruption happened, a stream of fresh
 “ water issued forth like a little river. Turning to-
 “ wards the place of the eruption, you saw mountains
 “ of smoak, part of which was very black and part
 “ very white, rise up to a great height; and in the
 “ midst of the smoke, at times, deep-coloured flames
 “ burst forth with huge stones and ashes, and you
 “ heard a noise like the discharge of a number of
 “ great artillery. It appeared to me as if Typhæus
 “ and Enceladus from Ischia and Etna with innume-
 “ rable giants, or those from the Campi Phlegrei
 “ (which according to the opinions of some were
 “ situated in this neighbourhood), were come to
 “ wage

“ wage war again with Jupiter. The natural histo-
 “ rians may perhaps reasonably say, that the wise
 “ poets meant no more by giants, than exhalations,
 “ shut up in the bowels of the earth, which, not
 “ finding a free passage, open one by their own force
 “ and impulse, and form mountains, as those which
 “ occasioned this eruption have been seen to do;
 “ and methought I saw those torrents of burning
 “ smoke that Pindar describes in an eruption of Etna,
 “ now called mon Gibello in Sicily, in imitation of
 “ which, as some say, Virgil wrote these lines :

“ *Ipse sed horrificis juxta tonat Ætna ruinis, &c.*

“ After the stones and ashes with clouds of thick
 “ smoke had been sent up, by the impulse of the
 “ fire and windy exhalation (as you see in a great
 “ cauldron that boils), into the middle region of the
 “ air, overcome by their own natural weight, when
 “ from distance the strength they had received from
 “ impulse was spent, rejected likewise by the cold
 “ and unfriendly region, you saw them fall thick,
 “ and by degrees, the condensed smoke clear away,
 “ raining ashes with water and stones of different
 “ sizes, according to the distance from the place :
 “ then by degrees with the same noise and smoke it
 “ threw out stones and ashes again, and so on by
 “ fits. This continued two days and nights, when
 “ the smoke and force of the fire began to abate.
 “ The fourth day, which was Thursday at 22 o'clock,
 “ there was so great an eruption, that, as I was in
 “ the gulph of Puzzole coming from Ischia, and
 “ not far from Misenum, I saw, in a short time,
 “ many

“ many columns of smoke shoot up, with the most
 “ terrible noise I ever heard, and, bending over the
 “ sea, came near our boat, which was four miles or
 “ more from the place of their birth; and the quan-
 “ tity of ashes, stones, and smoke, seemed as if they
 “ would cover the whole earth and sea. Stones, great
 “ and small, and ashes more or less, according to the
 “ impulse of the fire and exhalations, began to fall,
 “ so that a great part of this country was covered
 “ with ashes; and many that have seen it, say, they
 “ reached the vale of Diana, and some parts of
 “ Calabria, which are more than 150 miles from
 “ Pozzuolo. The Friday and Saturday nothing but
 “ a little smoke appeared, so that many, taking cou-
 “ rage, went upon the spot, and say, that with the
 “ stones and ashes thrown up, a mountain has been
 “ formed in that valley, not less than three miles in
 “ circumference, and almost as high as the monte
 “ Barbaro, which is near it, covering the Canettaria,
 “ the castle of Trepergule, all those buildings and
 “ the greatest part of the baths that were about
 “ them; extending South towards the sea, North as
 “ far as the lake of Avernus, West to the Sudatory,
 “ and joining East to the foot of the monte Barbaro,
 “ so that this place has changed its form and face in
 “ such a manner as not to be known again, a thing
 “ almost incredible to those who have not seen it,
 “ that in so short a time so considerable a mountain
 “ could have been formed. On its summit there is a
 “ mouth in the form of a cup, which may be a
 “ quarter of a mile in circumference, though some
 “ say it is as large as our market-place at Naples, from
 “ which there issues a constant smoke; and though

“ I have seen it only at a distance, it appears very
 “ great. The Sunday following, which was the
 “ 6th of October, many people going to see this
 “ phænomenon, and some having ascended half the
 “ mountain, others more, about 22 o'clock there
 “ happened so sudden and horrid an eruption, with
 “ so great a smoke, that many of these people were
 “ stifled, some of which could never be found. I
 “ have been told, that the number of the dead or
 “ lost amounted to twenty four. From that time
 “ to this, nothing remarkable happened; it seems
 “ as if the eruption returned periodically, like
 “ the ague or gout. I believe henceforward it
 “ will not have such force, though the eruption
 “ of the Sunday was accompanied with showers
 “ of ashes and water, which fell at Naples, and
 “ were seen to extend as far as the mountain of
 “ Somma, called Vesuvius by the ancients; and,
 “ as I have often remarked, the clouds of smoke
 “ proceeding from the eruption, moved in a
 “ direct line towards that mountain, as if these
 “ places had a correspondence and connection one
 “ with the other. In the night, many beams and
 “ columns of fire were seen to proceed from this
 “ eruption, and some like flashes of lightening.
 “ We have then, many circumstances for our obser-
 “ vation, the earthquakes, the eruption, the drying
 “ up of the sea, the quantity of dead fish and birds,
 “ the birth of springs, the shower of ashes with
 “ water, and without water, the innumerable trees
 “ in that whole country, as far as the Grotto of
 “ Lucullus, torn from their roots, thrown down, and
 “ covered with ashes, that it gave one pain to see
 E “ them:

“ them : and as all these effects were produced by
 “ the same cause that produces earthquakes ; let us
 “ first enquire how earthquakes are produced, and
 “ from thence we may easily comprehend the cause
 “ of the abovementioned events.” Then follows a
 dissertation on earthquakes, and some curious con-
 jectures relative to the phænomena which attended
 this eruption, clearly and well expressed, considering,
 as the author himself apologizes, that at that time the
 Italian language had been little employed on such
 subjects.

The account of the formation of the monte
 Nuovo, by Pietro Giacomo di Toledo, is given in a
 dialogue between the feigned personages of Peregrino
 and Sveffano ; the former of which says, “ It is now
 “ two years that this province of Campagna has been
 “ afflicted with earthquakes, the country about
 “ Pozzuolo much more so than any other parts, but
 “ the 27th and the 28th of the month of September
 “ last, the earthquakes did not cease day or night, in
 “ the abovementioned city of Pozzuolo ; that plain
 “ which lies between the lake of Averno, the monte
 “ Barbaro, and the sea, was raised a little, and many
 “ cracks were made in in it, from some of which
 “ issued water ; and at the same time the sea, which
 “ was very near the plain, dried up about two hun-
 “ dred paces, so that the fish were left on the sand,
 “ a prey to the inhabitants of Pozzuolo. At last, on
 “ the 29th of the said month, about two hours in
 “ the night, the earth opened near the lake, and dis-
 “ covered a horrid mouth, from which were vomited
 “ furiously, smoke, fire, stones, and mud composed
 “ of ashes ; making, at the time of its opening, a
 “ noise

“ noise like very loud thunder : the fire that issued
 “ from this mouth, went towards the walls of the
 “ unfortunate city ; the smoke was partly black and
 “ partly white, the black was darker than darkness
 “ itself, and the white was like the whitest cotton ;
 “ these smokes, rising in the air, seemed as if they
 “ would touch the vault of heaven ; the stones that
 “ followed, were, by the devouring flames, con-
 “ verted to pumice, the size of which (of some I say)
 “ were much larger than an ox. The stones went
 “ about as high as a cross-bow can carry, and then
 “ fell down, sometimes on the edge and sometimes
 “ into the mouth itself. It is very true that many of
 “ them in going up could not be seen, on account
 “ of the dark smoke ; but when they returned from
 “ the smoky heat, they shewed plainly where they
 “ had been by their strong smell of fetid sulphur,
 “ just like stones that have been thrown out of a
 “ mortar, and have passed through the smoke of in-
 “ flamed gunpowder. The mud was of the colour
 “ of ashes, and at first very liquid, then by degrees
 “ less so, and in such quantities, that in less than
 “ twelve hours, with the help of the abovementioned
 “ stones, a mountain was raised of a thousand paces
 “ in height. Not only Pozzuolo and the neighbour-
 “ ing country was full of this mud, but the city of
 “ Naples also, the beauty of whose palaces were, in
 “ a great measure, spoiled by it. The ashes were
 “ carried as far as Calabria by the force of the
 “ winds, burning up in their passage the grass and
 “ high trees, many of which were borne down by the
 “ weight of them. An infinity of birds also, and
 “ numberless animals of various kinds, covered with

“ this sulphureous mud, gave themselves up a prey
 “ to man. Now this eruption lasted two nights and
 “ two days without intermission, though, it is true,
 “ not always with the same force, but more or less;
 “ when it was at its greatest height, even at Naples
 “ you heard a noise or thundering like heavy artillery
 “ when two armies are engaged. The third day
 “ the eruption ceased, so that the mountain made its
 “ appearance uncovered, to the no small astonish-
 “ ment of every one who saw it. On this day,
 “ when I went up with many people to the top of
 “ this mountain; I saw down into its mouth, which
 “ was a round concavity of about a quarter of a mile
 “ in circumference, in the middle of which the
 “ stones that had fallen were boiling up, just as in
 “ a great cauldron of water that boils on the fire.
 “ The fourth day it began to throw up again, and
 “ the seventh much more, but still with less violence
 “ than the first night; it was at this time that many
 “ people, who were unfortunately on the mountain,
 “ were either suddenly covered with ashes, smothered
 “ with smoke, or knocked down by stones, burnt by
 “ the flame, and left dead on the spot. The smoke
 “ continues to this day, and you often see in the night
 “ the fire in the midst of it. Finally, to complete
 “ the history of this new and unforeseen event, in
 “ many parts of the new-made mountain, sulphur
 “ begins to be generated.” Giacomo di Toledo,
 towards the end of his dissertation upon the phæno-
 mena attending this eruption, says, that the lake of
 Avernus had a communication with the sea, before
 the time of the eruption; and that he apprehended
 that the air of Puzzole might come to be affected in
 summer

summer time, by the vapours from the stagnated waters of the lake, which is actually the case.

You have, Sir, from these accounts, an instance of a mountain, of a considerable height and dimensions, formed in a plain, by mere explosion, in the space of forty-eight hours. The earthquakes having been sensibly felt at a great distance from the spot where the opening was made, proves clearly, that the subterraneous fire was at a great depth below the surface of the plain; it is as clear that those earthquakes, and the explosion, proceeded from the same cause, the former having ceased upon the appearance of the latter. Does not this circumstance evidently contradict the system of M. Buffon, and of all the natural historians, who have placed the seat of the fire of volcanos towards the center, or near the summit of the mountains, which they suppose to furnish the matter emitted? Did the matter which proceeds from a volcano in an eruption come from so inconsiderable a depth as they imagine, that part of the mountain situated above their supposed seat of the fire must necessarily be destroyed, or dissipated in a very short time: on the contrary, an eruption usually adds to the height and bulk of a volcano, and who, that has had an opportunity of making observations on volcanos does not know, that the matter they have emitted for many ages, in lavas, ashes, smoke, &c. could it be collected together, would more than suffice to form three such mountains as the simple cone or mountain of the existing volcano? With respect to Vesuvius, this could be plainly proved; and I refer to my letter upon the subject of Etna, to shew the quantity of matter thrown up in one single eruption,

tion, by that terrible volcano. Another proof that the real seat of the fire of volcanos lies even greatly below the general level of the country whence the mountain springs, is, that was it only at an inconsiderable depth below the basis of the mountain, the quantity of matter thrown up would soon leave so great a void immediately under it, that the mountain itself must undoubtedly sink and disappear after a few eruptions.

In the above accounts of the formation of the new mountain, we are told that the matter first thrown up, was mud composed of water and ashes, mixed with pumice stones and other burnt matter: on the road leading from Puzzole to Cuma, part of the cone of this mountain has been cut away to widen the road. I have there seen that its composition is a *tufa* intermixed with pumice, some of which are really of the size of an ox, as mentioned in Toledo's account, and exactly of the same nature as the *tufa* of which every other high ground in its neighbourhood is composed; similar also to that which covers Herculaneum. According to the above accounts, after the muddy shower ceased, it rained dry ashes: this circumstance will account for the strata of loose pumice and ashes, that are generally upon the surface of all the *tufas* in this country, and which were most probably thrown up in the same manner. At the first opening of the earth, in the plain near Puzzole, both accounts say, that springs of water burst forth; this water, mixing with the ashes, certainly occasioned the muddy shower; when the springs were exhausted, there must naturally have ensued a shower of dry ashes and pumice, of which we have been likewise

likewise assured. I own, I was greatly pleased at being in this manner enabled to account so well for the formation of these *tufa* stones and the veins of dry and loose burnt matter above them, of which the soil of almost the whole country I am describing is composed; and I do not know that any one has ever attended to this circumstance, though I find that many authors, who have described this country, have suspected that parts of it were formed by explosion. Wherever then this sort of *tufa* is found, there is certainly good authority to suspect its having been formed in the same manner as the *tufa* of this new mountain; for, as I said before, nature is generally uniform in all her operations.

It is commonly imagined that the new mountain rose out of the Lucrine lake which was destroyed by it; but in the above account, no mention is made of the Lucrine lake; it may be supposed then, that the famous dam, which Strabo and many other ancient authors mention to have separated that lake from the sea, had been ruined by time or accident, and that the lake became a part of the sea before the explosion of 1538.

If the above described eruption was terrible, that which formed the monte Barbaro (or Gauro, as it was formerly called), must have been dreadful indeed. It joins immediately to the new mountain, which in shape and composition it exactly resembles; but it is at least three times as considerable. Its crater cannot be less than six miles in circumference; the plain within the crater, one of the most fertile spots I ever saw, is about four miles in circumference; there is no entrance to this plain, but one on the
East

East side of the mountain, made evidently by art; in this section you have an opportunity of seeing that the matter, of which the mountain is composed is exactly similar to that of the monte Nuovo. It was this mountain that produced (as some authors have supposed) the celebrated Falernian wine of the ancients.

Cuma, allowed to have been the most ancient city of Italy, was built on an eminence, which is likewise composed of *tufa*, and may be naturally supposed a section of the cone formed by a very ancient explosion.

The lake of Avernus fills the bottom of the crater of a mountain, undoubtedly produced by explosion, and whose interior and exterior form, as well as the matter of which it is composed, exactly resemble the monte Barbaro and monte Nuovo. At that part of the basis of this mountain which is washed by the sea of the bay of Puzzole, the sand is still very hot, though constantly washed by the waves; and into the cone of the mountain, near this hot sand, a narrow passage of about 100 paces in length is cut, and leads to a fountain of boiling water, which, though brackish, boils fish and flesh without giving them any bad taste or quality, as I have experienced more than once. This place is called Nero's bath, and is still made use of for a sudatory, as it was by the ancients; the stream that rises from the hot fountain above-mentioned, confined in the narrow subterraneous passage, soon produces a violent perspiration upon the patient who sits therein. This bath is reckoned a great specifick in that distemper which is supposed to have
6 made

made its appearance at Naples, before it spread its contagion over the other parts of Europe.

Virgil and other ancient authors say, that birds could not fly with safety over the lake of Avernus, but that they fell therein; a circumstance favouring my opinion that this was once the mouth of a volcano. The vapour of the sulphur and other minerals must undoubtedly have been more powerful the nearer we go back to the time of the explosion of the volcano; and I am convinced that there are still some remains of those vapours upon this lake, as I have observed there are very seldom any water fowl upon it; and that when they do go there, it is but for a short time, whilst all the other lakes in the neighbourhood are constantly covered with them, in the winter season. Upon mount Vesuvius, in the year 1766, during an eruption, when the air was impregnated with noxious vapours, I have myself picked up dead birds frequently.

The castle of Baïa stands upon a considerable eminence, composed of the usual *tufa* and strata of pumice and ashes, from which I concluded I should find some remains of the craters from whence the matter issued; accordingly, having ascended the hill, I soon discovered two very visible craters, just behind the castle.

The lake called the *Mare morto* was also, most probably, the crater from whence issued the materials which formed the Promontory of Misenum, and the high grounds around this lake. Under the ruins of an ancient building near the point of Misenum, in a vault, there is a vapour, or *mosete*, exactly similar in

its effects to that of the Grotto del Cane, as I have often experienced.

The form of the little island of Nisida shews plainly its origin. It is half a hollow cone of a volcano cut perpendicularly; the half crater forms a little harbour called the Porto Pavone; I suppose the other half of the cone to have been detached into the sea by earthquakes, or perhaps by the violence of the waves, as the part that is wanting is the side next to the open sea.

The fertile and pleasant island of Procita shews also most evident signs of its production by explosion, the nature of its soil being directly similar to that of Baïa and Puzzole; this island seems really, as was imagined by the ancients, to have been detached from the neighbouring island of Ischia.

There is no spot, I believe, that could afford a more ample field for curious observations, than the island of Ischia, called Enaria, Inarime, and Pithecusa, by the ancients. I have visited it three times; and this summer passed three weeks there, during which time, I examined, with attention, every part of it. Ischia is eighteen miles in circumference: the whole of its soil is the same as that near Vesuvius, Naples, and Puzzole. There are numberless springs, hot, warm, and cold, dispersed over the whole island, the waters of which are impregnated with minerals of various sorts; so that, if you give credit to the inhabitants of the country, there is no disorder but what finds its remedy here. In the hot months (the season for making use of these baths), those who have occasion for them flock hither from Naples.

A chari-

A charitable institution sends and maintains three hundred poor patients at the baths of Gurgitelli every season. By what I could learn of these poor patients, those baths have really done wonders, in cases attended with obstinate tumours, and in contractions of the tendons and muscles. The patient begins by bathing, and then is buried in the hot sand near the sea. In many parts of the island, the sand is burning hot, even under water. The sand on some parts of the shore is almost entirely composed of particles of iron ore; at least they are attracted by the load-stone, as I have experienced. Near that part of the island called Lacco, there is a rock of an ancient lava, forming a small cavern, which is shut up with a door; this cavern is made use of to cool liquors and fruit, which it does in a short time as effectually as ice. Before the door was opened, I felt the cold to my legs very sensibly; but when it was opened, the cold rushed out so as to give me pain, and within the grotto it was intolerable. I was not sensible of wind attending this cold; though upon mount Etna and mount Vesuvius, where there are caverns of this kind, the cold is evidently occasioned by a subterraneous wind: the natives call such places *ventaroli*. May not the quantity of nitre, with which all these places abound, account in some measure for such extreme cold? My thermometer was unluckily broken, or I would have informed you of the exact degree of the cold in this *ventaroli* of Ischia, which is by much the strongest in its effects I ever felt. The ancient lavas of Ischia shew, that the eruptions there have been very formidable; and history informs us, that its first inhabitants were driven out of the island

by the frequency and the violence of them. There are some of these ancient lavas not less than two hundred feet in depth. The mountain of St. Nicola, on which there is at present a convent of hermits, was called by the ancients Epomeus; it is as high, if not higher, than Vesuvius, and appears to me to be a section of the cone of the ancient and principal volcano of the island, its composition being all *tufa* or lava. The cells of the convent abovementioned are cut out of the mountain itself; and there you see plainly that its composition no way differs from the matter that covers Herculaneum, and forms the monte Nuovo. There is no sign of a crater on the top of this mountain, which rises almost to a sharp point; time, and other accidents, may be reasonably supposed to have worn away this distinctive mark of its having been formed by explosion, as I have seen to be the case in other mountains, formed evidently by explosion, on the flanks of Etna and Vesuvius. Strabo, in his 5th book, upon the subject of this island, quotes Timæus, as having said, that, a little before his time, a mountain in the middle of Pithecusa, called Epomeus, was shook by an earthquake, and vomited flames.

There are many other rising grounds in this island, that, from the nature of their composition, must lead one to think the same as to their origin. Near the village of Castiglione, there is a mountain formed surely by an explosion of a much later date, having preserved its conical form and crater entire, and producing as yet but a slender vegetation: there is no account, however, of the date of this eruption. Nearer the town of Ischia, which is on the sea shore,

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at a place called *Le Cremate*, there is a crater, from which, in the year 1301 or 1302, a lava ran quite into the sea; there is not the least vegetation on this lava, but it is nearly in the same state as the modern lavas of Vesuvius. Pontano, Maranti, and D. Francesco Lombardi, have recorded this eruption; the latter of whom says, that it lasted two months, that many men and beasts were killed by the explosion, and that a number of the inhabitants were obliged to seek for refuge at Naples and in the neighbouring islands. In short, according to my idea, the island of Ischia must have taken its rise from the bottom of the sea, and been increased to its present size by divers later explosions. This is not extraordinary, when history tells us (and from my own observation I have reason to believe) that the Lipary islands were formed in the like manner. There has been no eruption in Ischia since that just mentioned, but earthquakes are very frequent there; two years ago, as I was told, they had a very considerable shock of an earthquake in this island.

Father Goree's account of the formation of the new island in the Archipelago (situated between the two islands called Kammeni, and near that of Santorini) of which he was an eye-witness, strongly confirms the probability of the conjectures I venture to send you, relative to the formation of those islands and that part of the continent above described: it seems likewise to confirm the accounts given by Strabo, Pliny, Justin, and other ancient authors, of many islands in the Archipelago, formerly called the Cyclades, having sprung up from the bottom of the sea in the like manner. According to Pliny, in the

4th.

4th year of the cxxxv Olympiad, 237 years before the Christian æra, the island of Thera (now Santorini) and Theresia were formed by explosion; and, 130 years later, the island Hiera (now called the great Kammeni) rose up. Strabo describes the birth of this island in these words: "In the middle space between Thera and Therasia flames burst out of the sea for four days, which, by degrees, throwing up great masses, as if they had been raised by machines, they formed an island of twelve stadia in circuit." And Justin says of the same island, *Eodem anno inter insulas Theramenem et Theresiam, medio utriusque ripæ et maris spatio, terræ motus fuit: in quo, cum admiratione navigantium, repente ex profundo cum calidis aquis Insula emerfit.*

Pliny mentions also the formation of Aspronisi, or the White Island, by explosion, in the time of Vespasian. It is known, likewise, that in the year 1628, one of the islands of the Azores, near the island of St. Michael, rose up from the bottom of the sea, which was in that place 160 fathoms deep; and that this island, which was raised in fifteen days, is three leagues long, a league and a half broad, and rises three hundred and sixty feet above water.

Father Goree, in his account of the formation of the new island in the Archipelago, mentions two distinct matters that entered into the composition of this island, the one black, the other white. Aspronisi, probably from its very name, is composed of the white matter, which if, upon examination, should prove to be a *tufa*, as I strongly suspect, I should think myself still more grounded in my conjectures; though I must confess, as it is, I have scarcely a doubt

doubt left with respect to the country I have been describing having been thrown up in a long series of ages by various explosions from subterraneous fire. Surely there are at present many existing volcanos in the known world ; and the memory of many others have been handed down to us by history. May there not therefore have been many others of such ancient dates as to be out of the reach of history ?

Such wonderful operations of nature are certainly intended by all-wise Providence for some great purpose. They are not confined to any one part of the globe, for there are volcanos existing in the four quarters of it. We see the great fertility of the soil thrown up by explosion, in part of the country I have described, which on that account was called by the ancients *Campania Felix*. The same circumstance is evident in Sicily, justly esteemed one of the most fertile spots in the world, and the granary of Italy. May not subterraneous fire be considered as the great plough (if I may be allowed the expression) which nature makes use of to turn up the bowels of the earth, and afford us fresh fields to work upon, whilst we are exhausting those we are actually in possession of, by the frequent crops we draw from them ? Would it not be found, upon enquiry, that many precious minerals must have remained far out of our reach, had it not been for such operations of nature ? It is evidently so in this country. But such great enquiries would lead me far indeed. I will only add a reflection, which my own little experience in this branch of natural history furnishes me with. It is, that we are apt to judge of the great operations of nature on too confined a plan. When first I came to Naples,
my

my whole attention, with respect to natural history, was confined to mount Vesuvius, and the wonderful phenomena attending a burning mountain; but, in proportion as I began to perceive the evident marks of the same operation having been carried on in the different parts above described, and likewise in Sicily, in a greater degree, I looked upon mount Vesuvius only as a spot on which nature was at present active, and thought myself fortunate in having an opportunity of seeing the manner in which one of her great operations (an operation, I believe, much less out of her common course than is generally imagined) was effected.

Such remarks as I have made on the eruptions of mount Vesuvius, during my residence at Naples, have been transmitted to the Royal Society, who have done them more honour than they deserved. Many more might be made upon this active volcano, by a person who had leisure, a previous knowledge of the natural history of the earth, a knowledge of chemistry, and was practised in physical experiments, particularly those of electricity. I am convinced that the smoke of volcanos contains always a portion of electrical matter, which is manifest at the time of great eruptions, as is mentioned in my account of the great eruption of Vesuvius in 1767. The peasants in the neighbourhood of my villa, situated at the foot of Vesuvius, have assured me, that, during the eruption last mentioned, they were more alarmed by the lightening and balls of fire that fell about them with a crackling noise, than by the lava and the usual attendants of an eruption. I find in all the accounts of great eruptions mention made of this sort of lightening,

lightening which is distinguished here by the name of *Ferilli*. Bracini, in his account of the great one of Vesuvius in 1631, says, that the column of smoke, which issued from its crater, went over near an hundred miles of country, and that several men and beasts were struck dead by lightening, issuing from this smoke in its course.

The nature of the noxious vapours, called here *mofete*, that are usually set in motion by an eruption of the volcano, and are then manifest in the wells and subterraneous parts of its neighbourhood, seem likewise to be little understood. From some experiments very lately made, by the ingenious Dr. Nuth, on the *mofete* of the Grotto del Cane, it appears that all its known qualities and effects correspond with those attributed to fixed air. Just before the eruption of 1767, a vapour of this kind broke into the king's chapel at Portici, by which a servant, opening the door of it, was struck down. About the same time, as his Sicilian majesty was shooting in a paddock near the palace, a dog dropped down, as was supposed, in a fit; a boy going to take him up dropped likewise; a person present, suspecting the accident to have proceeded from a *mofete*, immediately dragged them both from the spot where they lay, in doing which, he was himself sensible of the vapour; the boy and the dog soon recovered. His Sicilian majesty did me the honour of informing me himself of this accident soon after it had happened. I have met with these *mofetes* often, when I have been making my observations on the borders of mount Vesuvius,

particularly in caverns, and once on the Solfaterra. The vapour affects the nostrils, throat, and stomach, just as the spirit of hartshorn, or any strong volatile salts, and would soon prove fatal if you did not immediately remove from it. Under the ancient city of Pompeii, the *mofetes* are very frequent and powerful, so that the excavations that are carrying on there are often interrupted by them; at all times *mofetes* are to be met with under ancient lavas of Vesuvius, particularly those of the great eruption of 1631. In Serao's account of the eruption of 1737, and in the chapter upon *mofetes*, he has recorded several curious experiments relative to this phenomenon. The Canonico Recupero, who, as I mentioned to you in a former letter, is watching the operations of mount Etna, has just informed me, that a very powerful *mofete* has lately manifested itself in the neighbourhood of Etna; and that he found near the spot from whence it rises, animals, birds, and insects, dead, and the stronger sort of shrubs blasted, whilst the grass and tenderer plants did not seem to be affected. The circumstance of this *mofete*, added to that of the frequent earthquakes felt lately at Rhegio and Messina, makes it probable that an eruption of mount Etna is at hand.

I am alarmed at the length of this letter. By endeavouring to make myself clearly understood, I have been led to make, what I thought, necessary digressions. I must therefore beg of your goodness, that, should you find this memoir in its present state, too tedious (which I greatly apprehend) to be presented

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fented to our respectable Society, you will make only such extracts from it as you shall think will be most agreeable and interesting. I am,

S I R,

With great truth and regard,

Your most obedient humble servant,

William Hamilton.

REFERENCES to the MAP, TAB. I.

1. Naples.
2. Portici.
3. Refina, under which Herculaneum is buried.
4. Torre del Greco.
5. Hermitage, at which travellers usually rest, in their way up mount Vesuvius.
6. St. Angelo, a convent of Calmaldolese, situated upon a cone of a mountain formed by an ancient explosion.
7. Cones formed by the eruption of 1760, and lava that ran from them almost into the sea.
8. Mount Vesuvius and Somma.
9. Village of Somma.
10. The convent of the Madonna del Arco, under which lavas have been found at 300 feet depth, and which must have proceeded from the mountain of Somma, when an active volcano.
11. Ottaiano.
12. Torre del Annunziata.
13. Castel a Mare, near which the ancient town of Stabia is buried, and where Pliny the elder lost his life.
14. Vico.
15. Sorrento, and the plain formed evidently by subterraneous fire.
16. Massa.
17. Island of Caprea.
18. The

18. The Grotto of Paufilipo, cut through the mountain anciently, to make a road from Naples to Puzzole.
19. Point of Paufilipo.
20. The Gaiola, where there are ruins of ancient buildings, supposed to have belonged to Lucullus.
21. The island of Nisida, evidently formed by explosion.
22. The Lazaret.
23. The Bagnoli.
24. Puzzole, or Pozzuolo.
25. The Solfaterra, anciently called Forum Vulcani: between the Solfaterra and the lake of Agnano, are the boiling waters of the Pisciarelli.
26. The New Mountain, formed by explosion in the year 1538; the sand of the sea shore at its basis burning hot.
27. The lake of Agnano, supposed the crater of an ancient volcano: here are the baths called St. Germano, and the famous Grotto del Cane.
28. Astruni, which has been evidently a volcano, and is now a Royal Chace, the crater being surrounded with a wall.
29. The monte Gauro or Barbaro, anciently a volcano.
30. The lake of Avernus, evidently the crater of an ancient volcano.
31. Lake of Fusaro.
32. Point of Milenum, from whence Pliny the elder discovered the eruption of Vesuvius that proved fatal to him; near this place, in a vault of an ancient building, is a constant vapour
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or *mosfete*, of the same quality with that of the Grotto del Cane.

33. The Mare Morto, the ancient Roman Harbour.
34. Baïa ; behind the castle are two evident craters of ancient volcanos.
35. Island of Procita.
36. A perfect cone and crater of a volcano near Castiglione in the island of Ischia.
37. Lava that ran into the sea in the last eruption on this island, in the year 1301, or 1302 ; the place now called Le Cremate.
38. Town of Ischia and castle.
39. Lake of Licola.
40. Lake of Patria.
41. The river Volturnus.
42. Capua.
43. Caserta.
44. Averfa.
45. Mataloni.
46. Acerra.
47. Island of Ischia, anciently called Ænaria, Inarime, and Pithecusa.
48. The mountain of St. Nicola, anciently called Mons Epomeus, supposed the remains of the principal volcano of the island.
49. Castiglione, near which are the baths of Gurgitelli.
50. Lacco, near which is that very cold vapour called by the natives *ventarole*.
51. Ancient city of Pompeii, where his Sicilian majesty's excavations are carrying on at present.
52. Rovigliano.
53. River of Sarno.

54. Cu-

54. Cuma.
55. Hot sands and Sudatory called Nero's baths.
56. The Lucrine lake supposed to have been here,
and of which there is still some little remain.
57. Villa Angelica, Mr. Hamilton's villa, from
whence he has made many of his observations upon mount Vesuvius.
58. Cones formed by an ancient eruption called
viuli ; here are likewise cold vapours called
ventaroli.
59. High grounds, probably sections of cones of an-
cient volcanos, being all composed of *tufa* and
strata of loose pumice and burnt matter.
60. Plain of the Campagna Felice, four or five feet
of excellent soil, under which are strata of
burnt and erupted matter.
- Marks the boundary of Mr. Hamilton's
observations.

II. *Extract of another Letter, from Mr. Hamilton, to Dr. Maty, on the same Subject.*

Naples, March 5, 1771.

SINCE I had the pleasure of sending you my letter, in which the nature of the soil of more than twenty miles round this capital is described; examining a deep hollow way cut by the rain waters into the outside cone of the Solfaterra, I discovered, that a great part of the cone of that ancient volcano has been calcined by the hot vapours above described. Pumice calcined seems to be the chief ingredient, of which several specimens of (as I suppose) variegated uniform marble are composed, and the beautiful variegations in them may have probably been occasioned by the mineral vapours. As these specimens are now sent to the Royal Society, you will see that these variegations are exactly of the same pattern and colours as are met in many marbles and flowered alabasters; and I cannot help thinking that they are marble or alabaster in its infant state. What a proof we have here of the great changes the earth we inhabit is subject to! What is now the Solfaterra, we have every reason to suppose, to have been originally thrown up by a subterraneous explosion from the bottom of the sea. That it was long

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an existing volcano, is plain, from the ancient currents of lava, that are still to be traced from its crater to the sea, from the strata of pumice and erupted matter, of which its cone, in common with those of all other volcanos, is composed, and from the testimony of many ancient authors. Its cone in many parts has been calcined, and is still calcining, by the hot vapours that are continually issuing forth through its pores, and its nature is totally changed by this chemical process of nature. In the hollow way, where I made these remarks, you see the different strata of erupted matter, that compose the cone, in some places perfectly calcined, in others not, according as the vapours have found means to insinuate themselves more or less.

A hollow way cut by the rains on the back of the mountain, on which part of Naples is situated, towards Capo di China, shews that the mountain is composed of strata of erupted matter, among which are large masses of bitumen, in which its former state of fluidity is very visible. Here it was I discovered that pumice stone is produced from bitumen, which I believe has not yet been remarked. Some specimens shew evidently the gradual process from bitumen to pumice; and you will observe that the crystalline vitrifications, that are visible in the bitumen, suffer no alteration, but remain in the same state in the perfect pumice as in the bitumen.

In a piece of stratum, calcined from the outside of the Solfaterra, the form and texture of the pumice stones is very discernible. In several parts of the outside cone, this calcining operation is still carried on by the exhalation of constant very hot

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and damp vapours, impregnated with salts, sulphur, alum, &c. Where the above-mentioned vapours have not operated, the strata of pumice and erupted matter, that compose the cone of the Solfaterra, are like those of all the high grounds in its neighbourhood, which I suppose to have been thrown up likewise by explosion. I have seen here, half of a large piece of lava perfectly calcined, whilst the other half out of the reach of the vapours has been untouched; and in some pieces the center seems to be already converted into true marble.

The variegated specimens then, above described, are nothing more than pumice and erupted matter, after having been acted upon in this manner by the hot vapours; and if you consider the process, as I have traced it, from bitumen to pumice, and from pumice to marble, you will think with me that it is difficult to determine the primitive state of the many wonderful productions we see in nature.

I found in the *tufa* of the mountain of Pausilipo, a fragment of lava: one side I polished, to shew it to be true lava; the other shews the signs of the *tufa*, with which it is incorporated. It has evidently been rounded by friction, and most probably by rolling in the sea. Is it not natural then to imagine that there must have been volcanoes near this spot, long before the formation of the mountain of Pausilipo? This little stone may perhaps raise in your mind such reflections, as it did in mine, relative to the great changes our globe suffers, and the probability of its great antiquity.

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